Editorial

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Biographical notes: Peter Mayr is an Assistant Professor at the Institute of Materials Science and Welding of Graz University of Technology. He heads the materials development group and his work mainly targets the development of improved creep resistant steels for application in thermal power generation. He is the Chairman of the sub-commission 'Creep and heat-resistant welds' of the International Institute of Welding. At present, he is a Visiting Scientist at the Department of Materials Science and Engineering of Massachusetts Institute of Technology. He has published several refereed journal papers on creep, welding and materials development and a book chapter on creep resistant welded joints at Woodhead Publishing.

Janez Grum is a Professor of Materials Science, Heat Treatment and Surface Engineering. He is also the Founder and Editor-in-Chief of a new journal, the *Int. Journal of Microstructure and Materials Properties (IJMMP)* and has been the Editor of the *Non-Destructive Testing News* issued by the Slovenian NDT Society. He has published more than 200 refereed journal papers and more than 400 conference papers. He has published five books with several reprints and five book chapters at ASM, Marcel Dekker and Taylor and Francis Publishers.

The present special issue of the *Int. Journal of Microstructure and Materials Properties* comprises ten papers on 'laser materials processing'.

Lasers represent one of the most important inventions of the 20th century. With their development it was possible to get a highly intensive, monochromatic, coherent, highly polarised light wave. The first laser was created in 1960 in Californian laboratories with the aid of a resonator from an artificial ruby crystal. Dating from this period is also the first industrial application of laser, which was used to make holes in diamond materials extremely difficult to machine. First applications of laser metal machining were not particularly successful mostly due to low capability and instability of laser sources in different machining conditions. These first applications, no matter how successful they were, have however led to the development of a number of new laser source types.

Laser is becoming a very important engineering tool for cutting, welding, and to a certain extent for heat treatment. Laser technology provides a light beam of extremely high power density acting on the workpiece surface. The input of the energy necessary for heating up the surface layer is achieved by selecting from a range of scan speeds of the workpiece and laser beam source power. The first laser welds were made around 1963 and involved butt and edge joints in 0.25 mm stainless steel foils, processed with a pulsed ruby laser. Other studies into conduction-limited welding in metals report that the technique was applied to joining wires, sheets, and circuit boards shortly afterward when 0.5 mm was the maximum penetration. Various laser-based conduction joining techniques have been developed, including soldering and brazing, partly in response to the needs of the microelectronics industries.

Early data in 1966 were mostly a by-product of investigations into the interaction between materials and the focused beams of pulsed ruby and Nd: glass lasers. Investigations of interactions between pulsed ruby laser radiation and a graphite-coated metal surface gave some indication of the potential for metal hardening.

Laser surface remelting and the possibilities of surface alloying were investigated in 1963, mainly with pulsed solid-state lasers, in which shallow surface alloys were produced. At the same time, the mechanism of laser-induced vaporisation including shock hardening was also studied.

The first gas-assisted carbon dioxide laser beam was made in 1967 for cutting and scribing. A 300 W laser beam coaxial with an oxygen jet was used to cut 1 mm thick steel using a potassium chloride lens, an aluminised beam turning mirror, and parameters that were very close to those used today. The early 1980s produced a generation of industrial CO_2 lasers that featured higher powers, greater reliability, and more compact designs.

In 1968, the first mathematical models of heat flow provided greater insight into the role of the process variables in determining the thermal cycles induced and the geometry of the hardened region.

When ultrafast lasers with pulse lengths in the order of femtoseconds were developed in the 1980s, interest was renewed by the automotive and aerospace industries. The 1980s were notable for the development of integrated laser systems, which comprised a laser source, beam handling optics, and workpiece handling equipment. User-friendly interfaces were developed to provide information and instant control to the operator. Researchers also turned to novel methods of using the laser beam for materials processing, rather than a direct replacement for a conventional process.

The dominant Nd:YAG lasers available in the early 1980s were pulsed units, the maximum average power available from a commercial unit was 500 W and 1 kW. This was proceeded by the development of fibre-optic cable that could transmit a suprakilowatt near infrared beam with flexible optics mounted on an industrial robot. With Nd:YAG laser, complex geometry three-dimensional components were now able to be treated economically.

In the field of laser welding, progress was made with new welded joint designs, novel material combinations, and thick section welding which led to improvements in quality, productivity, and environmental friendliness. Progress was made in 1985 by understanding the physics of keyhole formation and stability, which provided greater confidence in the welding process. At the same time, reliable high-power industrial lasers were becoming available. This was followed by applying metallic coatings to a metallic substrate by the interaction of a directed laser beam and a gas stream containing entrained particles. The coating material was used with the blown powder process for producing hardfaced aeroengine turbine blades. Blown powder cladding is now the most popular laser-based surfacing technique, finding uses in the aerospace, automotive, power generation, and machine tool industries, as well as forming the basis of a rapid manufacturing technique.

Papers gathered in this double issue are spontaneous and include the following topics:

- laser melt injection of ceramics in titanium alloys, high strength steels and aluminium alloys
- laser cladding and casting
- laser shock processing of various aluminium alloys
- laser remelting and rapid solidification of various aluminium alloys and nodular cast irons
- laser drilling of small diameter holes in glass
- influence of different He-Ar ratios at high power CO_2 laser welding on process optimisation and weld formations
- investigations of process parameters for Nd: YAG pulsed laser welding various stainless steel types
- applications of laser hybrid welding
- study of the GMA-hybrid welding according to type of applied filler materials.

We sincerely hope that the papers presented on laser materials processing will be valuable source of information to readers and engineers in their professional activities.

Special thanks are due to the authors contributing their papers to this issue of the *IJMMP*. They are the results of the very critical work of reviewers and the authors. It can be said that the papers satisfy high standards quality.

Special thanks go to Prof. Dr. H. Cerjak and Dr. P. Mayr from the Institute for Materials Science and Welding of Graz University of Technology who selected four papers presented at Int. Conf. Safety and Reliability of Welded Components in Energy and Processing Industry. These papers discuss the latest developments in laser welding and hybrid laser welding.